

**ESTIMATING RIO GRANDE WILD TURKEY DENSITIES IN TEXAS**

A Dissertation

by

SHAWN LEE LOCKE

Submitted to the Office of Graduate Studies of  
Texas A&M University  
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2007

Major Subject: Wildlife and Fisheries Sciences

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## ABSTRACT

Estimating Rio Grande Wild Turkey Densities in Texas.

(August 2007)

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Rio Grande wild turkeys (*Meleagris gallopavo intermedia*) are a highly mobile, wide ranging, and secretive species located throughout the arid regions of Texas. As a result of declines in turkey abundance within the Edwards Plateau and other areas, Texas Parks and Wildlife Department initiated a study to evaluate methods for estimating Rio Grande wild turkey abundance. Unbiased methods for determining wild turkey abundance have long been desired, and although several different methods have been examined few have been successful. The study objectives were to: (1) review current and past methods for estimating turkey abundance, (2) evaluate the use of portable thermal imagers to estimate roosting wild turkeys in three ecoregions, and (3) determine the effectiveness of distance sampling from the air and ground to estimate wild turkey densities in the Edwards Plateau Ecoregion of Texas. Based on the literature review and the decision matrix, I determined two methods for field evaluation (i.e., infrared camera for detecting roosting turkeys and distance sample from the air and ground). I conducted eight ground and aerial forward-looking infrared (FLIR) surveys (4 Edwards Plateau, 3 Rolling Plains, and 1 Gulf Prairies and Marshes) of roost sites during the study. In the

three regions evaluated, I was unable to aerially detect roosting turkeys using the portable infrared camera due to altitudinal restrictions required for safe helicopter flight and lack of thermal contrast. A total of 560 km of aerial transects and 10 (800 km) road based transects also were conducted in the Edwards Plateau but neither method yielded a sufficient sample size to generate an unbiased estimate of the turkey abundance. Aerial and ground distance sampling and aerial FLIR surveys were limited by terrain and dense vegetation and a lack of thermal contrast, respectively. Study results suggest aerial FLIR and ground applications to estimate Rio Grande wild turkeys are of limited value in Texas. In my opinion, a method for estimating Rio Grande wild turkey densities on a regional scale does not currently exist. Therefore, the Texas Parks and Wildlife Department should reconsider estimating trends or using indices to monitor turkey numbers on a regional scale.

## **DEDICATION**

I dedicate my dissertation to my wife Dana who loves and supports me unconditionally. I wrote this dissertation primarily during our first year of marriage causing both of us more stress and anxiety than wanted for newlyweds. However, she continues to amaze me with her faith, patience, and love. Thank you and I love you.

## **ACKNOWLEDGEMENTS**

First, I would like to thank God for giving me the strength and persistence to pursue and complete my doctoral research. I also would like to thank my parents (Carl and Marie Locke) who have always supported me in everything I choose to do. Next, I would like to thank Dr. Roel Lopez for being an advisor and a friend, and for treating me like a colleague. Additionally, I thank the other members of my committee Drs. Nova Silvy, Markus Peterson, and Sorin Popescu for their assistance and willingness to provide guidance when it was needed. I also would like to thank the Texas Parks and Wildlife Department for funding, logistical support, and for allowing me to conduct this research. I would like to thank the many landowners and managers that granted me and other graduate students access to their property and provided me with logistical support in initially locating turkeys. Finally, I would like to thank the other graduate students in the Department of Wildlife and Fisheries Sciences for their dedication and continued friendship.

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## CHAPTER I

### INTRODUCTION

The foundation of many wildlife studies is an unbiased estimate of population abundance (Krebs 1999). Wildlife management is dependent upon sound abundance estimates (Bowden et al. 2003), and a survey is an important factor in determining the population size of a species, habitat requirements, reasons for species decline, whether habitat management has improved site conditions, or to understand other aspects of population dynamics (Sutherland 1996). Populations are often categorized by their size as increasing, decreasing, or stable and managed accordingly to achieve a desired level (Lancia et al. 1996). Game populations are often maintained at levels which provide a harvestable surplus of animals without affecting the population's health or growth potential (Miller and Wentworth 2000). Thus, reliable and unbiased density estimates are necessary for such management practices.

Obtaining accurate and reliable estimates of density, however, can be difficult for species that are highly mobile, wide ranging, and secretive (Lewis 1967, Bull 1981, Williams and Austin 1988). This is especially true of the wild turkeys (*Meleagris gallopavo*). Methods for accurately determining wild turkey abundance have long been desired (Cook 1973, DeYoung and Priebe 1987, Dickson 1992). Although several different methods have been examined the majority were of limited success (Weinstein

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This dissertation follows the style of The Journal of Wildlife Management.

et al. 1995, Cobb et al. 2001) because of low observability and the difficulty in obtaining an adequate sample sizes (Healy and Powell 1999).

The lack of an effective method to monitor wild turkey abundance with accuracy, precision, and statistical power is a common challenge (Graves 1982, Zeedyk and Dickson 1985, Cobb et al. 1997). Long-term abundance data are needed to evaluate responses of wild turkey to changing land-use patterns on a broad scale (Weinstein et al. 1995, Cobb et al. 2001). Ideally, a monitoring protocol would provide data from a large proportion of the population, calibrate to population status (i.e., population size), and be cost, manpower, and equipment efficient (Cobb et al. 2001). Reliable, long-term population estimates would greatly improve our knowledge of the effects of changing land-use patterns and allow the ability to predict and better manage wild turkey populations (Weinstein et al. 1995).

Rio Grande wild turkeys (*M. G. intermedia*) historically were distributed in the arid habitats of Oklahoma, Kansas, Texas, and Mexico (Beasom and Wilson 1992). Up to 2 million birds were thought to occupy the United States prior to European settlement, but human civilization has had a dramatic impact on wild turkey numbers. Habitat destruction, habitat conversion, and over hunting have reduced wild turkey populations and numbers throughout their range (Beasom and Wilson 1992). Turkey restoration efforts began in the early 20<sup>th</sup> century and much of the transplant stock originated from turkey strongholds in the Edwards Plateau of Texas (Figure on page 5; Peterson et al. 2002). Numerous studies have been conducted on Rio Grande wild turkeys including food habits (Litton 1977, Beasom and Pattee 1978, Pattee and Beasom 1979, 1981,

Randel et al. 2007), infectious diseases (Glazener 1967, Peterson et al. 2002), nesting habitats (Cook 1972, Randel et al. 2005, Metz et al. 2006), productivity (DeArment 1959, Beasom 1970, Beasom and Pattee 1980, Schwertner et al. 2005), brood sex ratios (Collier et al. 2007b), winter roost sites (Crockett 1973, Haucke and Ables 1972, Haucke 1975), movements (Wigley et al. 1986), survival (Willsey 2003, Collier et al. 2007a), and habitat use (Baker 1979, Baker et al. 1980, Randel 2003). However, few studies (Cook 1973, DeYoung and Priebe 1987) have evaluated methods for estimating Rio Grande wild turkey abundance.

Despite being a stronghold for turkeys, Texas Parks and Wildlife Department biologist have recognized declines in turkey abundance in parts of the Edwards Plateau since the 1970's (Texas Parks and Wildlife Department, unpublished data). A reliable, unbiased method for estimating turkey abundance at a broad scale (i.e., ecoregion) is necessary for better management particularly to understand the cause(s) of decline and to determine densities to establish regional bag limits. Therefore, the objectives of this study were as follows:

1. Review current and past methods for estimating wild turkey abundance (Chapter II).
2. Evaluate the use of portable thermal imagers to estimate roosting wild turkeys in 3 ecoregions (Chapter III).
3. Determine the effectiveness of distance sampling from the air and ground to estimate wild turkey densities in the Edwards Plateau Ecoregion of Texas (Chapter IV).

I will conclude my dissertation with management recommendations and implications. Each chapter within my dissertation is meant to stand alone as an independent paper therefore a certain amount of repetition will occur among chapters. A description of all the study areas for my project is provided below, however, a study area description is provided in each relevant chapter.

### **Study area**

Rio Grande turkeys are distributed in the central-western regions of Texas (Beasom and Wilson 1992), occupying 3 Ecological Regions: Edwards Plateau (EP), Rolling Plains (RP), and Gulf Prairies and Marshes (GPM). The EP Ecoregion contains approximately 9.7 million ha (Fig. 1.1). The region was predominately rangeland with various species of bluestem (*Andropogon* spp.), grama (*Bouteloua* spp.), and panicum (*Panicum* spp., Gould 1962). Common overstory species included semi-evergreen live oak (*Quercus virginiana*) and evergreen ashe juniper (*Juniperus ashei*). Other deciduous overstory species, bald cypress (*Taxodium distichum*), cottonwood (*Populus deltoides*), and pecan (*Carya illinoensis*) were found along riparian zones to a lesser degree (Larkin and Bomar 1983). The EP consisted of rolling hills, steep canyons, and ranges in elevation from approximately 30–915 m above sea level (ASL) (Gould 1962). The climate of the EP is subtropical to semi-arid, with mean annual precipitation from 84 cm/year on the eastern edge to 38 cm/year on the western edge; droughts occur frequently.

The RP Ecoregion is approximately 9.7 million ha within the Great Plains Region of North America (Fig. 1.1, Gould 1962). The RP was predominately rangeland

and primarily consisted of tall- and mid-grasses including various species of bluestem, grama, tobosa (*Pleuraphis mutica*), and three-awn (*Aristida* spp.). Deciduous mesquite

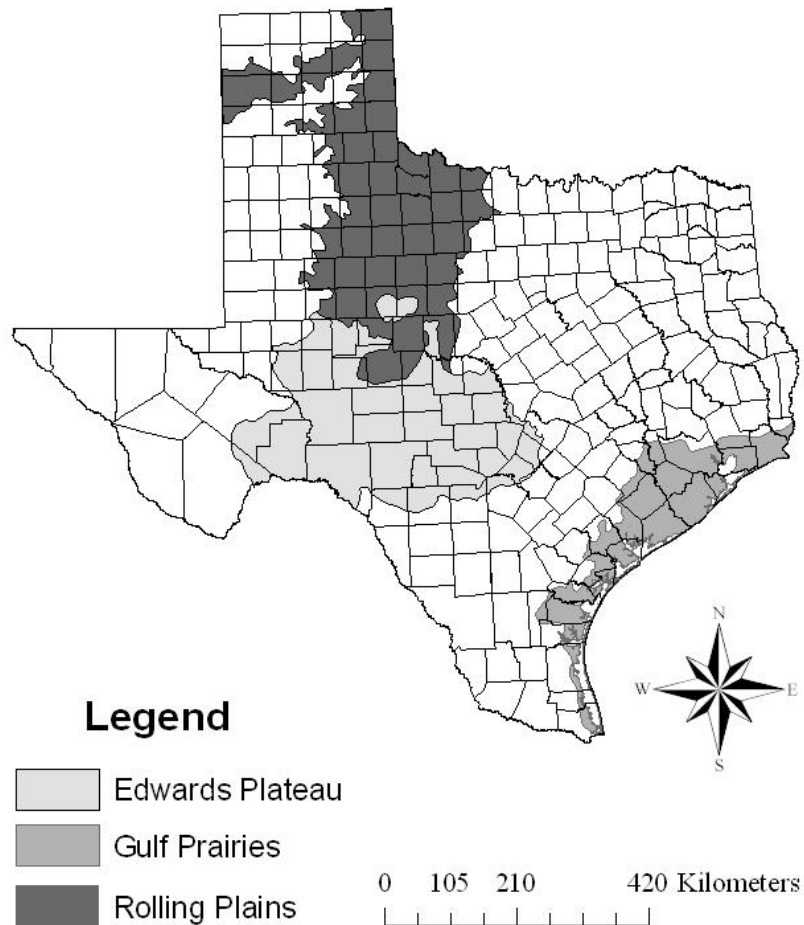


Figure 1.1. Study area locations in the Edwards Plateau, Rolling Plains, and Gulf Prairies and Marshes Ecoregions, Texas.

(*Prosopis glandulosa*), low-lying shinnery oak (*Q. harvardii*), and sand sage (*Artemisia filifolia*) were common invader species. Large cottonwood and pecan trees were found along the riparian areas. Topography was characterized as gently rolling to moderately rough and elevation ranged between 243–914 m ASL. The climate is semi-arid, and

mean annual precipitation varied from 55–76 cm in the western and eastern portions, respectively.

The GPM Ecoregion, located along the Gulf Coast of Texas, is approximately 3.8 million ha (Fig. 1.1, Gould 1962). The GPM was a mixture of rangeland, improved pasture, and woodlands. Typical rangeland species included bluestem, Indian grass (*Sorghastrum nutans*), and gulf muhly (*Muhlenbergia capillaries*). Trees species such as mesquite and live oak have invaded along with brush species including prickly pear (*Opuntia* spp.) and acacia (*Acacia* spp.). Topography generally was flat and  $\leq 46$  m above sea level. Mean annual precipitation varied from 50–127 cm from west to east, respectively.

## CHAPTER II

### LITERATURE REVIEW

The inability to obtain unbiased abundance estimates of wild turkeys (*Meleagris gallopavo*) at a reasonable cost is a limitation of turkey management (Zeedyk and Dickson 1985, Cobb et al. 1997). Although numerous approaches have been evaluated most were of limited success. The variety of approaches reflects the lack of a single method that is unbiased and precise under a broad range of conditions (Cobb et al. 2001).

Rio Grande wild turkeys (*M. g. intermedia*) are distributed throughout the western portion of Texas within a variety of vegetation (Beasom and Wilson 1992). Since the 1970s, Texas Parks and Wildlife Department (TPWD) has documented a decline in turkey numbers for parts of the Edwards Plateau and other areas in Texas. Currently, TPWD conducts summer production surveys and harvest surveys to provide gross estimates of reproductive success and population trends. However, neither method is effective at detecting biologically meaningful changes in recruitment or density at regional scales (Schwertner et al. 2003). In 2001, TPWD in conjunction with Texas A&M University and Texas Tech University, initiated projects to evaluate methods for estimating Rio Grande wild turkey densities at regional scales. The goal was to provide a method(s) that could provide unbiased, reliable estimates of turkey density at the ecoregion scale for the purpose of establishing biologically relevant harvest regulations.

The objective of this chapter was to review current and past methods applicable for estimating wild turkeys and to determine suitable methods to be further evaluated.



From the literature review, I constructed a decision matrix (Caughley and Sinclair 1994) using existing conceptual frameworks for determining density estimation methods (Lancia et al. 1996, Thompson et al. 1998). A decision matrix is often used to map out a decision process while including various considerations (i.e., biological, economic, or social) to determine the most appropriate action (Caughley and Sinclair 1994). My decision matrix was developed to decide upon methods that would be used to estimate Rio Grande wild turkey densities in Texas and particularly in the Edwards Plateau. A list of selection criteria to determine applicable methods were selected *a priori* by me in conjunction with TPWD biologists. Criteria included methods that were: (1) technically practical (e.g., could the method be implemented in the Edwards Plateau with current manpower and equipment available), (2) economically feasible (would the method be cost-effective for TPWD to conduct on annual or semi-annual basis), (3) provided adequate accuracy and precision (satisfactory accuracy and precision to facilitate management decisions), and (4) could be conducted without violating underlying assumptions. The following subsections include a brief background of each method, a literature review and my assessment as to the viability of the method. The results of the decision matrix are presented at the end of this chapter.

### **Direct winter roost and flock counts**

Total counts of animals are difficult to obtain especially for animals ranging over large areas (Lancia et al. 1996). A complete census can be effectively employed where animal populations are small or highly concentrated. Rio Grande turkeys display a propensity to form stable winter groups (Porter 1978) and to exhibit strong fidelity to

traditional roost sites (Watts and Stokes 1971, Cook 1973). Thomas et al. (1966) recommended taking advantage of this behavior and count roosting Rio Grande turkeys to determine current population distributions and trends.

Cook (1973) used landowners and biologists in the Edwards Plateau of Texas to locate and count concentrations of roosting Rio Grande turkeys. Traditional roost sites were located in the Edwards Plateau, and winter (December, January, and February) counts were conducted in the mornings and evenings. Counts were made by landowners and verified by biologists for comparison. Landowners tended to overestimate turkey numbers where roost sites were unstable, which suggested double counting due to flock movement (Healy and Powell 1999). Where roost sites were stable, landowner counts were similar to biologist counts (7%). A shorter census period can minimize this problem (Weinrich et al. 1985) where turkey movements are considerable. Smith (1975) also reported variable roosting patterns of turkeys in south Texas decreased the reliability of roost counts. Roosting patterns were affected by human activity, land-use practices, availability of roost sites, and the heightened sensitivity of small flocks (Smith 1975). Cook (1973) concluded that estimates made by landowners can be used to estimate populations and determine Rio Grande turkey trends where there is little movement among roost sites. A statistical sample rather than a complete count of roosting turkeys may provide a quick and reliable estimate (Cook 1973).

DeArment (1975) used counts of wintering Rio Grande turkey flocks in the Texas Panhandle along with fall harvest data to determine the percent of population harvested, percent of each sex harvested, and an average adjusted population.

Evaluations of the flock counts were not provided, but due to insufficient time and personnel a complete census was not conducted the last 2 years of the 4-year study. This resulted in a decreasing population trend (DeArment 1975).

Weinrich et al. (1985) described a technique used for a winter census of wild turkeys in Michigan and its relationship with spring harvest. Winter flock counts were conducted during a 2-week period each January by 6–8 people. A complete census was not attempted and observers used observations from mail carriers, school bus drivers, United Parcel Service drivers, and local residents. Harvest estimates were based on a mail survey of turkey hunters. Winter flock counts and spring harvest estimates had a positive correlation ( $r = 0.74$ ,  $P < 0.05$ ), and Weinrich et al. (1985) concluded that winter flock counts were a valid method for estimating wild turkey trends.

In review, roost counts and flock counts conducted on the ground could potentially provide an applicable method of estimating Rio Grande turkey number in the Edwards Plateau. However, due to the large scale of the area, shifts in roost sites in some areas and the amount of private land ownership in Texas including the Edwards Plateau (Wagner and Kreuter 2004), roost counts may not be a technically practical way of estimating abundance. These methods may have potential if done aurally which could be applied across the landscape and avoid potential difficulties with land access.

### **Distance sampling**

Line and strip transects are commonly used methods for estimating animal densities. The theory of line transects assumes that all animals on the transect line are observed, their location is fixed at the point where they are first sighted, distances and

angles to animals are recorded accurately, and observations are independent events (Burnham et al. 1980). Guthery (1988) added that animals should not be counted more than once, and the creation of the transect line does not influence animal distribution. Strip transects are based on the assumption that all animals within the strip are detected (Buckland et al. 2001), which may be a difficult assumption to meet due vegetation characteristics or other confounding factors.

DeYoung and Priebe (1987) compared line and strip transects for their ability to inventory Rio Grande turkeys in south Texas. Turkeys were captured and marked, and a drive route for the line and strip transects was established. The 16-km routes were surveyed in the mornings and the evenings, and data were pooled to form a 129-km transect (DeYoung and Priebe 1987). The line-transect estimate was greater than the strip-transect estimate, and the line-transect estimate had a larger and wider standard error and 95% confidence interval, respectively. The authors also had difficulty meeting all of the assumptions for both methods. The creation of a line transect should not influence the distribution of the animal (Guthery 1988). This assumption may have been violated because turkeys were using roads as spring display sites. It also is questionable whether all turkeys within 100 m of the strip transect were seen due to dense vegetation. Although neither estimator performed particularly well, line transects were recommended for further evaluation because of its potential for broad applicability (DeYoung and Priebe 1987).

Butler et al. (2005) observed the relationship between Rio Grande wild turkey distributions and roads in the panhandle of Texas and Kansas. Their results suggested

that distance sampling from roads during the winter (morning) and autumn (midday) seasons would provide less biased estimates. Other times of the year and day would result in biased estimates due to turkeys being attracted to or avoiding roads. Therefore, distance sampling may provide unbiased estimates of turkeys but only during certain times of the year.

The assumptions of strip transects are difficult to meet, and strip transects may be too variable to provide accurate estimates over time. Line transects may have more potential due to their broad applicability. Line transects could be conducted on low traffic, public roads that effectively cover the area of interest and survey through major vegetation types. Using public roads will help to avoid difficulties with land access and routes can be standardized and used annually. Observing a sufficient sample size of turkeys may be difficult due to the broad scale, topography, and vegetation within the region.

### **Aerial surveys**

Aerial surveys conducted from fixed-wing aircraft and helicopters offers an alternative to traditional survey methods. Aerial surveys are often thought of as a subset of plot, quadrat, or transect methodology (Krebs 1999). Large areas can be surveyed quickly in an aircraft, and can circumvent problems with land accessibility due to a lack of roads or private land ownership. However, aerial surveys also create new problems (Seber 1982, Caughley 1977, Buckland et al. 2001). Accuracy of aerial surveys can be greatly affected by animal sightability, transect width, altitude, speed, experience of

observers, and other confounding factors (Caughley 1974, Caughley et al. 1976, Seber 1982, Krebs 1999).

Wild turkey and other species of wildlife have been successfully surveyed using aerial methods (Thompson and Baker 1981). Kubisiak et al. (1997) compared helicopter counts to ground counts of eastern wild turkeys (*M. g. silvestris*) in Wisconsin. Ground counts consisted of counting wintering concentrations of turkeys using radio-telemetry procedures, and helicopter counts were conducted by flying transects within a systematically random block design. Number of flocks and number of turkeys counted were slightly less from aerial counts but did not differ ( $P = 0.16$ ) statistically among years. Kubisiak et al. (1997) suggested undercounting increased with increasing flock size, and concluded that helicopter counts offer a reliable alternative in surveying turkeys though turkey movement was minimized by deep snow.

Beasom (1970) estimated Rio Grande turkey populations in south Texas using road and aerial transects. Road counts were conducted along 2 (24-km) transects twice/day in the morning and evening. Aerial transects were flown in the morning, independent of road direction and sampled 2 dominate habitats. Road counts produced turkey densities >twice that of the aerial transects; however, the focus of the research was not to compare the methods, therefore, no inferences were made as to the validity or accuracy of either method.

In reviewing the applicability of the method to my study, aerial methods in conjunction with transects or distance methods of sampling (i.e., line transects) pose sufficient promise for estimating Rio Grande turkey abundance. Large areas can be

effectively surveyed in a short amount of time. However, aerial surveys can be expensive and may be difficult to conduct in varying topography and dense vegetation.

### **Infrared imagery**

The advent of new technology such as thermal-infrared cameras, have recently gained broad attention for its potential in mammal surveys (Garner et al. 1995). The use of aerial forward-looking infrared (FLIR) may improve the accuracy of population surveys (Havens and Sharp 1998), but have been used primarily for large ungulate species like white-tailed deer (*Odocoileus virginianus*) and moose (*Alces alces*, Wiggers and Beckerman 1993, Naugle et al. 1996, Adams et al. 1997). Few studies have evaluated the ability of FLIR to detect and survey smaller wildlife species.

Garner et al. (1995) evaluated the ability of FLIR to detect multiple species of varying sizes including wild turkeys in differing New York state habitats. Transects were flown using a fixed-wing aircraft equipped with an infrared camera. Radio-marked turkeys were located and concentric circles were flown for complete coverage of the flock. Ground counts were conducted prior to and after aerial counts for comparison. Garner et al. (1995) determined that turkeys within open areas were easily identified while turkeys in dense vegetation were obscured. The authors concluded their method required additional research in order to determine the ability of the technology to differentiate between objects of interest (i.e., species), and should be compared with other survey methods to validate accuracy and precision.

Wakeling et al. (1999) used fixed-wing aircraft equipped with FLIR to determine if night-time roosting Merriam's turkeys (*M. g. merriami*) could be detected in a

ponderosa pine (*Pinus ponderosa*) habitat in Arizona. Radio-marked turkeys were followed to roosting trees and the corresponding coordinates were provided to the pilot. The aircraft flew concentric circles around the roost site, but detection of roosting turkeys was not successful at 3 separate roost sites (Wakeling et al. 1999). Wakeling et al. (1999) suspects that turkeys may have been obscured by dense canopy, and recommends that aerial FLIR surveys not be solely relied upon especially for smaller species.

Although FLIR surveys have not proven to be an effective means of estimating turkeys, this may be a result of the time of year the survey was conducted or the capability of the FLIR camera. Graves et al. (1972) suggested that summer may be more effective in producing distinguishable signatures of the target (i.e., animal). Therefore, surveys should be conducted during different times of the year as well as differing times of the day (early morning and late night) to determine optimal times to conduct surveys. Infrared technology and capabilities have increased greatly over the past decade. Currently, smaller, more powerful thermal cameras are commercially available at reasonable cost.

### **Mark-recapture/resight**

Mark-recapture/resight techniques involve the capture and marking of individuals and the subsequent recapture(s) or resighting of marked and unmarked animals to determine population size (Bibby et al. 1992, Krebs 1999). Mark-recapture/resight techniques are classified as closed or open population estimators. A closed population does not change in size during the study (i.e., births, deaths,



emigration, and immigration are negligible). An open population does change in size during the study period due to births, deaths, or movement of animals into or out of the area of interest (Krebs 1999). A number of estimators (e.g., Petersen, Schnabel, and Jolly-Seber) exist but the general assumption of mark-recapture is the proportion of marked individuals in the sample is similar to the proportion of marked individuals in the population.

DeYoung and Priebe (1987) compared the mark-resight method with line and strip transects in south Texas. A 16-km survey route was used to evaluate the 3 methods. Using a modified Petersen estimator, the mark-resight method had the lowest abundance estimate of the 3 methods (DeYoung and Priebe 1987), in addition to the smallest standard error and 95% confidence intervals. DeYoung and Priebe (1987) concluded that none of the estimators were completely adequate and the mark-resight technique was too time consuming and costly for practical purposes.

Weinstein et al. (1995) evaluated 2 mark-recapture and 2 mark-resight methods for estimating eastern wild turkey populations in Mississippi. Turkeys were captured and marked during the winter and observations of turkeys at bait sites were conducted during the summer. The Jolly-Seber full (Jolly 1965) and Buckland (Buckland 1980) estimators were used to analyze mark-recapture data. Minta-Mangel (Minta and Mangel 1989) and Arneson et al. (1991) estimators were used to analyze mark-resight data, and abundance estimates were converted to densities to allow for comparisons. Weinstein et al. (1995) determined that abundance estimates using the Jolly-Seber full and Buckland methods were weak with wide 95% confidence intervals. Minta-Mangel (1989) and

Arneson et al. (1991) methods performed well especially when the marked sample size was large although the assumption of independent resighting was probably violated (Weinstein et al. 1995). Weinstein et al. (1995) concluded that mark-recapture techniques were insufficient in estimating turkey populations and required excessive resources to obtain an adequate sample size. Although assumptions may have been violated, the authors were optimistic about the mark-resight technique because of its potential for broad applicability (Weinstein et al. 1995).

Cobb et al. (2001) evaluated 6 wild turkey population estimation techniques in Florida for their ability to monitor trends. Turkeys were captured and marked, and resight surveys were conducted along bait station transects (Cobb 1990) and unbaited transects. The authors estimated abundance using: maximum likelihood estimate through Monte Carlo simulations (Minta and Mengal 1989), change-in-ratio (Paulik and Robson 1969), mean Peterson and Peterson based on means (Eberhardt 1990), Schnabel index (Ricker 1975), and the Buckland model (Buckland 1980). The maximum likelihood estimate, Buckland model, and change-in-ratio estimators were removed because the insufficient number of marked individuals produced abundance estimates  $<0$ . The Peterson based-on-means method produced the lowest abundance estimate and lowest coefficient of variation. Cobb et al. (2001) acknowledged that none of the estimators were satisfactory for estimating or monitoring populations, and estimates should be compared with known populations.

In review, mark-recapture/resight techniques are theoretically sound (Healy and Powell 1999) and can potentially provide information on population dynamics (Pollock

et al. 1990, Bibby et al. 1992, Caughley and Sinclair 1994). These techniques, however, often are costly and labor-intensive (DeYoung and Priebe 1987, Weinstein et al. 1995). Assumptions of the methods frequently are difficult to meet and subsequently may produce biased population estimates (Seber 1982). Mark-resight techniques should be evaluated against known populations. Marking a known sub-sample of the population preferably with radio-transmitters allows the assumption of closure to be evaluated. Location of known animals can determine whether the population is truly closed and how many known animals are actually alive during the survey (White and Shenk 2001). Abundance estimates from mark-resight methods have been tested with known populations of large ungulates (Rice and Harder 1977, Silvy et al. 1977, Leslie and Douglas 1986, Bartmann et al. 1987, Neal et al. 1993) as well as smaller mammals like coyotes (*Canis latrans*; Hein and Andelt 1995). However, I believe mark-recapture/resight techniques are too time consuming and costly to conduct on a broad spatial scale such as an ecoregion. Mark-resight methods should be used to establish a known population and provide a basis upon which population comparisons can be made.

### **Cameras and infrared sensors**

The use of cameras at bait sites is often considered a derivative of mark-resight methods and has been used to estimate populations of white-tailed deer (*Odocoileus virginianus*; Jacobson et al. 1997, Koerth et al. 1997, Roberts et al. 2005), black bears (*Ursus americanus*; Martorello et al. 2001), feral pigs (*Sus scrofa*; Sweitzer et al. 2000), and wild turkeys (Cobb et al. 1996). Surveys conducted with the use of cameras are often time and man power efficient but may not be economical for short-term periods.

Cobb et al. (1996) conducted a pilot study using infrared triggered cameras at bait stations to validate a bait-station-transect survey of turkey populations in Florida. TrailMaster<sup>®</sup> cameras were established at 5 bait stations along a transect route. The stations were prebaited 7 days prior to the 14-day survey, and cameras were installed 3 days prior to the survey. Transect surveys were driven in the mornings and evenings and turkeys observed were recorded by sex and age. Cameras were set to record activity between 0630 and 2100 hours each day during the study. The bait-station-transect surveys did not generate data that accurately represented use of the bait stations based on data generated from the infrared triggered cameras. Due to the inability to accurately record sex and age data during the transect surveys, hen:poult ratios were not calculated, but ratios were documented from the camera data. Initial costs of the infrared camera surveys were substantial but could be extrapolated over multiple years for long-term monitoring. Cobb et al. (1996) concluded that infrared triggered camera surveys were promising and could be used to monitor turkey trends or validate other survey techniques.

Cobb et al. (1997) outlines 7 assumptions pertaining to baiting and sampling design of a study using infrared triggered cameras to monitor wild turkey populations. First, observability of turkeys whose home range overlaps bait sites has the same probability of being observed at any site in any habitat. Secondly, an individual whose ranges overlaps bait sites is not modified by annual fluctuations in habitat use. Bait stations are adequately spaced to allow only 1 sighting of each individual during a survey replicate. Individuals have an equal probability of being observed at any bait site

despite age or sex class. Individuals have the same probability of being observed at any site within temporal limits of a survey. When at a bait site, all individuals have the same probability of being observed. Finally, the sex and age class of marked individuals is readily identifiable from photographs. Cobb et al. (1997) conclude that meeting the assumptions creates consistency in data collection, and once the technique is validated and calibrated long-term monitoring can be conducted at a reasonable cost with relatively high accuracy.

Sweitzer et al. (2000) used a mark-resight approach with infrared-triggered cameras to estimate the size and density of wild pig populations in California. Using 54 camera stations at various study sites in the North and Central Coast regions, data was collected for both marked and unmarked wild pigs, and analyzed with NOREMARK (White 1996) to provide a population estimate. The population estimates and density estimates generated from NOREMARK (White 1996) had narrow 95% confidence intervals and low standard errors, respectively in the study areas where the sample size of marked individuals was large. Obtaining the large sample sizes of marked animals took considerable amounts of time, effort, and costs due to the amount of trapping necessary, and the costs of numerous camera stations. Sweitzer et al. (2000) suggests the camera-survey system is beneficial in producing a minimum population value and a mark-resight population estimate, and the method can be cost effective if conducted over long-term periods.

In review, the application of infrared triggered cameras is too costly and time consuming to be effective for Rio Grande wild turkeys over a broad spatial scale.

Cameras also would require abundant landowner cooperation, which may not be feasible over long periods of time. A great deal of time and effort would be required to monitor picture status and collecting film or digital media.

### **Removal methods**

Change-in-ratio and catch-per-unit-effort estimators are the 2 general types of removal methods (Healy and Powell 1999). The change-in-ratio method requires the population be composed of 2 types of organisms (i.e., males and females, or adults and juveniles), and a differential change in these 2 organisms during the study period (Krebs 1999). The catch-per-unit-effort method is often used with exploited populations and can estimate abundance using the decline in catch-per-unit-effort over time (Krebs 1999). However, if there is not a decline in catch-per-unit-effort over time, which is typical of large populations, this method is ineffective (Krebs 1999). Removal methods are based on the assumption that the population is closed (Caughley and Sinclair 1994), but Seber (1982) offers a catch-per-unit-effort technique for open populations.

Lint et al. (1995) compared a Buckland (1980) wild turkey population estimate in Mississippi to indices using spring gobbler harvest, harvest/hunter effort, and gobblers heard/day. The Buckland estimate showed a decreasing trend in wild turkeys during the 9-year study and was related to harvest/hunter effort and harvested gobblers but not to gobblers heard/day. Harvested gobblers was correlated with gobblers heard/day ( $r = 0.88$ ,  $P = 0.002$ ), and harvest/hunter effort and gobblers heard/day ( $r = 0.83$ ,  $P = 0.006$ ) were correlated. Obtaining the data necessary to estimate abundance based on harvested

gobblers was the least expensive method because hunters were required to return permit cards at self-service harvest stations.

In sum, the application of removal methods for estimating Rio Grande wild turkey abundance are too time consuming. The capture and tagging of animals requires a great deal of time and effort and would have to be conducted on a periodic basis.

### **Map plotting technique**

The personal interview-map plotting technique was at one time considered the most suitable method for estimating turkey numbers (Mosby and Handley 1943). Interviews of hunters, wildlife and forestry professionals, landowners, mail carriers, and other knowledgeable people are used to determine location, and size of known turkey flocks (Zirkle 1982). These locations are then plotted on a map and adequate population size and distribution can be estimated for management purposes (Zirkle 1982). Solitary gobblers, however, may not be accurately estimated (Weaver and Mosby 1979), and this technique is time consuming and probably not efficient on a large scale.

Map plotting would not be an effective means of accurately estimating turkey populations on a broad scale. It also is imprecise and would be time consuming to conduct interviews with knowledgeable people.

### **Decision matrix**

The decision analysis matrix (Fig. 2.1) was constructed based on whether the abundance estimation method was achievable or unachievable. For selection criteria where there were insufficient data to support either, I assumed the method was achievable until further evaluation. Alternatives that did not meet at least 1 selection

	Criteria			
Alternatives	Technically Practical	Economical	Accuracy & Precision	Assumptions Satisfied
Winter Roost Count		X	X	X
Distance Sampling	X	X	X	X
Aerial Surveys	X	X	X	X
FLIR Roost Count	X	X	X	X
Mark-Recapture	X		X	
Trail Cameras	X			
Removal Methods	X			
Map Plotting	X			

Figure 2.1. Decision matrix for determining methods for estimating Rio Grande wild turkey densities in the Edwards Plateau of Texas. Alternatives were examined based on criteria and scored as either being achievable (X), or unachievable (blank). Untested methods were deemed achievable until further evaluation. Alternatives meeting all criteria were evaluated via pilot studies.

criteria were deemed “fatally flawed” and excluded from field evaluation (Fig. 2.1). Based on my feasibility assessment using the decision analysis matrix, I identified 2 density estimation methods as feasible alternatives: (1) aerial sampling of roost sites using forward-looking infrared and (2) distance sampling methods from an aerial and ground perspective. Further evaluation of feasible alternatives was conducted in the field via pilot studies. In Chapter III I discuss the evaluation of portable infrared cameras for detecting roosting turkeys in 3 ecoregions of Texas. Chapter IV evaluates



the use of distance sampling from the air and ground to estimate Rio Grande wild turkey densities in the Edwards Plateau of Texas.

## **CHAPTER III**

### **EVALUATION OF PORTABLE INFRARED CAMERAS**

#### **Introduction**

Many wildlife are nocturnal, cryptic, highly mobile, or elusive; therefore, observing them in the field is problematic (Boonstra et al. 1994). The foundation of many wildlife studies is to obtain a precise, unbiased estimate of abundance (Krebs 1999). Estimates of abundance are required to evaluate the impact of management activities (Kurzejeski and Vangilder 1992, Weinstein et al. 1995), establish harvest regulations (Kurzejeski and Vangilder 1992), and model population dynamics (Vangilder 1992). Due to the mobility and evasive behavior of many species, abundance estimates are difficult to obtain. Wild turkeys exemplify a species where numerous abundance estimation methods have been evaluated with limited success (Cook 1973, Weinstein et al. 1995), which constrains wild turkey management programs (Cobb et al. 1997). Reliable methods for estimating wild turkey numbers at broad spatial scales have long been sought by natural resource agencies (Cook 1973, Weinstein et al. 1995).

The advent of technology such as thermal-infrared cameras recently has gained broad attention for potential use in wildlife population surveys (Garner et al. 1995, Thompson 2004). The use of forward-looking infrared (FLIR) may improve the detection of individuals, thus increasing survey precision (Havens and Sharp 1998). Aerial FLIR has been used primarily for large ungulate species (Wiggers and Beckerman 1993, Naugle et al. 1996, Adams et al. 1997), and few studies have evaluated the ability of FLIR to detect and survey smaller wild animals. As with all species, estimating wild

turkey abundance is dependent upon detectability (Thompson et al. 1998, Buckland et al. 2001), which is influenced by various factors including vegetation, terrain, weather, and observer experience (Buckland et al. 2001). Researchers have reported an increase in detection of target species with the use of FLIR (Belant and Seamans 2000, Focardi et al. 2001). Evaluation of FLIR for detecting wild turkeys is limited (Wakeling et al. 1999), particularly across a range of various cover types, and no one has evaluated the effectiveness of FLIR technology for aerially detecting roosting Rio Grande wild turkeys. Recent declines in turkey abundance have prompted Texas Parks and Wildlife Department (TPWD) to assess regional methods of surveying turkey abundance. Brood counts and harvest data have been used by TPWD to estimate abundance trends and numbers, but presently no methods to estimate Rio Grande wild turkey densities are used. Here I describe an application of FLIR technology in detecting wild turkeys in 3 Texas ecological regions where they commonly are found (Edwards Plateau, Rolling Plains, and Gulf Prairies and Marshes; Gould 1962). I sought to estimate turkey abundance using aerial thermal imaging surveys and to assess the accuracy of these estimates by comparing to independent estimates from ground surveys.

### **Study area**

Rio Grande turkeys are distributed in the central-western regions of Texas (Beasom and Wilson 1992), occupying 3 Ecological Regions: Edwards Plateau (EP), Rolling Plains (RP), and Gulf Prairies and Marshes (GPM). The EP Ecoregion contains approximately 9.7 million ha (Fig. 1.1). The region was predominately rangeland with various species of bluestem (*Andropogon* spp.), grama (*Bouteloua* spp.), and panicum

(*Panicum* spp., Gould 1962). Common overstory species included semi-evergreen live oak (*Quercus virginiana*) and evergreen ashe juniper (*Juniperus ashei*). Other deciduous overstory species, bald cypress (*Taxodium distichum*), cottonwood (*Populus deltoides*), and pecan (*Carya illinoensis*) were found along riparian zones to a lesser degree (Larkin and Bomar 1983). The EP consisted of rolling hills, steep canyons, and ranges in elevation from approximately 30–915 m above sea level (ASL), (Gould 1962). The climate of the EP is subtropical to semi-arid, with mean annual precipitation from 84 cm/year on the eastern edge to 38 cm/year on the western edge; droughts occur frequently.

The RP Ecoregion is approximately 9.7 million ha within the Great Plains region of North America (Fig. 1.1, Gould 1962). The RP was predominately rangeland and primarily consisted of tall- and mid-grasses including various species of bluestem, grama, tobosa (*Pleuraphis mutica*), and three-awn (*Aristida* spp.). Deciduous mesquite (*Prosopis glandulosa*), low-lying shinnery oak (*Q. harvardii*), and sand sage (*Artemisia filifolia*) were common invader species. Large cottonwood and pecan trees were found along the riparian areas. Topography was characterized as gently rolling to moderately rough and elevation ranged between 243–914 m ASL. The climate is semi-arid, and mean annual precipitation varied from 55–76 cm in the western and eastern portions, respectively.

The GPM Ecoregion, located along the Gulf coast of Texas, is approximately 3.8 million ha (Fig. 1.1, Gould 1962). The GPM was a mixture of rangeland, improved pasture, and woodlands. Typical rangeland species included bluestem, Indian grass

(*Sorghastrum nutans*), and gulf muhly (*Muhlenbergia capillaries*). Trees species such as mesquite and live oak have invaded along with brush species including prickly pear (*Opuntia* spp.) and acacia (*Acacia* spp.). Topography generally was flat and  $\leq 46$  m ASL. Mean annual precipitation varied from 50–127 cm from west to east, respectively.

## Methods

I collected data similarly among the 3 ecoregions. To aid in estimating turkey detectability, birds were captured and outfitted with a back-pack style, motion-sensitive, radio transmitter (150–152 MHz, Advanced Telemetry Systems, Asanti, Minn.) in conjunction with concurrent research projects (Texas A&M University, Texas A&M University–Kingsville, Texas Tech University). Radiomarked turkeys allowed me to readily locate numerous roost sites across study areas. The evening prior to an aerial survey, roost sites of radiomarked turkeys were located via homing (White and Garrott 1990) and I estimated flock size via ground counts. I estimated ground counts of roosting turkeys in 1 of 2 ways: (1) I established ground blinds near roost sites and counted turkeys as they flew into the trees, or (2) I located roost sites at night via homing radiomarked turkeys and counted them using a spotlight with a red filter, binoculars, or the portable FLIR camera. Universal Transverse Mercator (UTM) coordinates of the roost sites were recorded with a hand-held global positioning system. I collected ambient temperature, wind speed, humidity, and cloud cover information from the ground.

Aerial FLIR surveys were conducted from a Robinson R-22 helicopter (Holt Helicopters, Uvalde, Tex.; Flap Air, Canadian, Tex.; Mesquite Helicopters, Alice, Tex.)

using a FLIR ThermaCAM<sup>®</sup> B-20 (FLIR Systems, North Billerica, Mass.) handheld infrared camera with a 24° lens. The B-20 is a long-wave (7.5–13- $\mu$ m) infrared camera with a thermal sensitivity of 0.06°C at 30°C. The 24° lens provides a field of view of 24°  $\times$  18° and minimum focus distance of 0.3 m with a spatial resolution of 320  $\times$  240 pixels. A built-in 10-cm liquid crystal display (LCD) viewfinder allowed the operator to view real-time images and zoom in to potential targets. A built-in flash memory and 128-megabyte removable flash-card allowed the operator to store radiometric thermal images.

I performed surveys (1–4 flights/region) during predawn hours (0300–0600) of winter months (Nov 2004–April 2005) to take advantage of the leaf-off period for each ecological region. Additionally, Rio Grande wild turkeys form large flocks in the winter and congregate at traditional roost sites typically located along riparian areas (Thomas et al. 1966, Beasom and Wilson 1992). I hand-held the FLIR camera out the passenger side door of the helicopter, which was removed to maximize the field of view (Havens and Sharp 1998). The pilot navigated to the roost sites based on the UTM coordinates collected from the ground and orbited around the roost while slowly decreasing in altitude until turkeys were detected or until it was unsafe to fly any lower. Using a helicopter allowed the pilot and FLIR operator to hover over potential targets and search for thermal signatures of roosting turkeys. Flight altitudes differed by study area due to topography and aerial obstructions (e.g., utility poles, towers, and wires). I recorded aerial survey data to a VHS video tape and compared data to ground counts to determine the proportion of turkeys detected. Radiant surface temperatures of turkeys and their

surroundings were captured on the radiometric thermal images and analyzed using the ThermaCam QuickView 1.1 analysis software (FLIR Systems, North Billerica, Mass.).

## **Results**

I conducted 8 ground and aerial FLIR surveys (4 EP, 3 RP, and 1 GPM) of roost sites during the study period. During the study, I located 3 roosts in the EP, with 2 roosts of 28–33 turkeys and the third roost consisting of 14–17 turkeys. The RP roost sites consisted of a large roost with 66–75 turkeys and a smaller roost with 47–52 turkeys. I located 9 roost sites in the GPM and each included 5–15 turkeys. Ground counts were estimates of roosting turkeys, and variation in counts was due to actual changes in the number of turkeys from night to night or counting error. In this study, I was unable to aurally detect roosting turkeys using the portable infrared camera due to altitudinal restrictions required for safe helicopter flight and lack of thermal contrast. Based on the analysis of the radiometric thermal images, I found the external temperatures of turkeys, tree branches, and other background objects (i.e., rocks, bare ground) to be within 1.5°C of each other despite ambient temperatures or other weather variables (i.e., wind speed, humidity, and cloud cover). Therefore, there was not sufficient difference in the radiant temperature of a turkey and its background to permit adequate detection from an aerial perspective.

## **Discussion**

Use of FLIR technology in aurally detecting Rio Grande wild turkeys in 3 ecological regions of Texas was limited for various reasons. First, flight altitude was a principal obstacle as topography and aerial obstructions often required higher-altitude

flights than ideal for turkey observation, most notably in the EP. I found thermal signatures for wild turkeys to be small (Buchholz 1996); thus, flights <10–15 m above the tree canopy were required for observation of turkeys. Aerial surveys at this altitude were (1) unsafe for proposed landscape aerial surveys and (2) resulted in turkeys flushing from the roosts prior to completing counts. Further, the required thermal contrast to differentiate between a target of interest (i.e., turkeys) and its background (i.e., branches of roost trees; Wyatt et al. 1985) was inadequate. Radiant temperatures of the background (i.e., tree, leaves, ground cover), in each study location retained and emitted energy throughout the night, making it difficult to detect turkeys. Thus, heat signatures of roosting turkeys effectively were camouflaged within the rest of the tree from an aerial perspective (Fig. 3.1A). However, roosting turkeys were more readily detected from the ground (horizontal view) using the portable infrared camera because the background consisted of the cool night sky (Fig. 3.1B). Finally, I observed Rio Grande wild turkeys in the RP and EP preferred to roost in riparian areas, typically on branches overhanging water (Thomas et al. 1966, Cook 1973, Crockett 1973). Because water retains heat even if ambient temperatures are low (i.e., near or  $<0^{\circ}\text{C}$ ), turkeys roosting over water were camouflaged and difficult to differentiate from an aerial perspective (Fig. 3.2). Therefore, I suspect that if the flight altitude had been lower, detection still would have been limited.

The combination of inadequate thermal contrast caused by background objects and the required altitude needed to adequately detect roosting Rio Grande turkeys (due to small thermal signature) limited the use of FLIR technology for all 3 Texas study



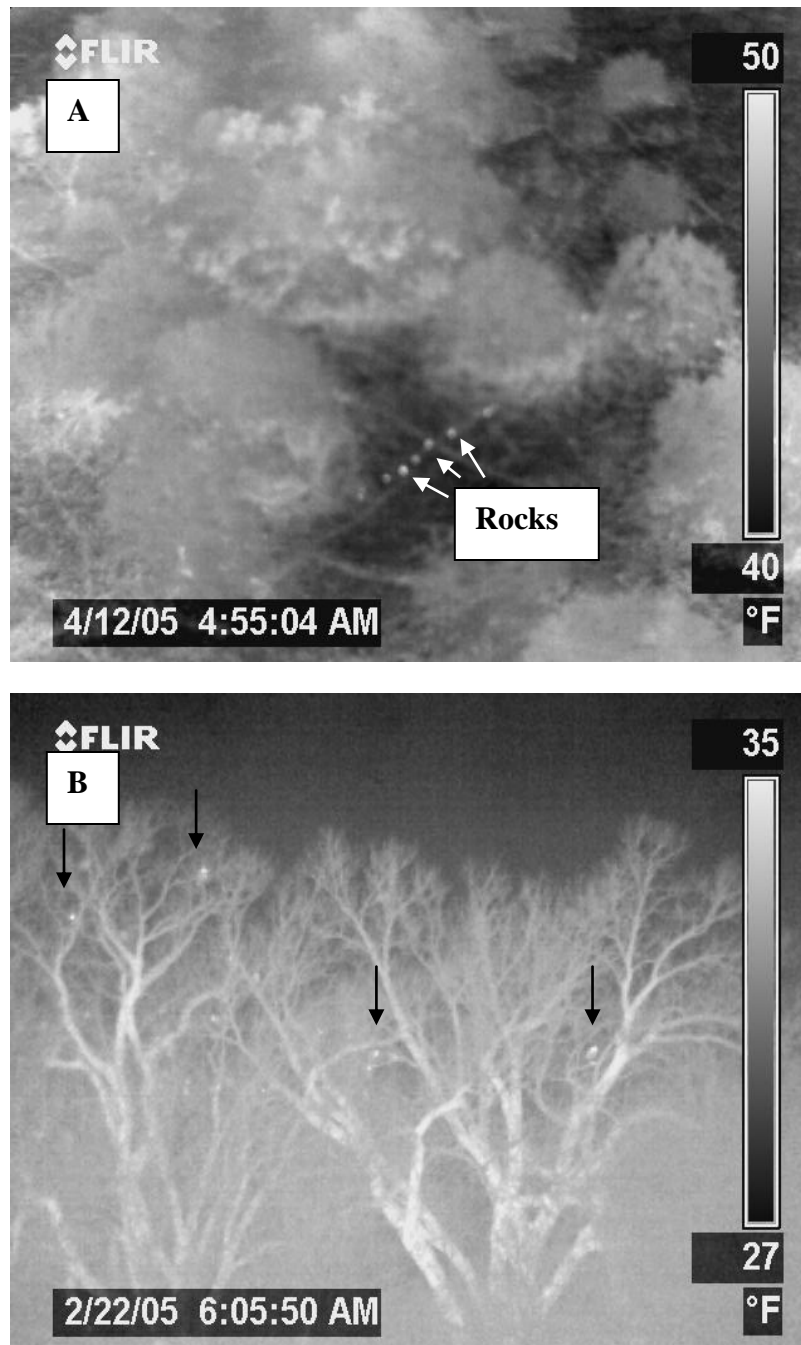


Figure 3.1. Aerial image of Rio Grande wild turkey roost sites (note heat signature from inanimate objects, photo A was taken approximately 10–15 m above the canopy) in the Gulf Prairies and Marshes. Horizontal view from the ground of roosting wild turkeys (delineated with arrows, photo B) in the Rolling Plains.



Figure 3.2. Aerial views of Rio Grande wild turkey roost sites along the Medina River in the Edwards Plateau (A) and live oak woodlands (B) in the Gulf Prairies and Marshes. Wild turkeys could not be observed due to heat signatures from nontarget objects and dense semi-evergreen overstory cover, respectively.

areas. These findings were similar to those reported by Wakeling et al. (1999) in aerial surveys of Merriam's wild turkeys (*M. g. merriami*) in northern Arizona. They concluded dense ponderosa pine (*Pinus ponderosa*) canopy obscured turkeys and thermal signatures were too small to detect with an infrared camera. Although the tree species in this study differed, I confronted similar complexities. Due to the limitations of aerial FLIR surveys for wild turkeys, I recommend TPWD seek alternative methods for estimating Rio Grande wild turkey densities in the state of Texas. Unless the technology improves, FLIR should not be considered as a viable method for surveying Rio Grande wild turkeys in Texas

## **CHAPTER IV**

### **EVALUATION OF LINE TRANSECTS**

#### **Introduction**

The ability to obtain unbiased estimates of wild turkey abundance or trends has been a continual limitation of management programs (Cobb et al. 1997, Cobb et al. 2001). Difficulties are increased when dealing with economic constraints, detection limitations (i.e., elusive species, steep terrain, or dense vegetation), predominately private lands, and large scale areas (e.g., physiographic regions). A number of methods for estimating turkey abundance in a variety of conditions have been evaluated with limited success (Kurzejeski and Vangilder 1992, Cobb et al. 1997, Cobb et al. 2001). Some of the previous methods include roost counts (Cook 1973, Weinrich et al. 1985), mark-recapture (DeYoung and Priebe 1987, Weinstein et al. 1995), harvest data (Eberardt 1982, Lint et al. 1995, Cobb et al. 2001), line transects from roads (DeYoung and Priebe 1987, Butler et al. 2005), aerial surveys (Kubisiak et al. 1997), infrared-triggered cameras (Cobb et al. 1996), and thermal imaging (Garner et al. 1995, Wakeling et al. 1999, Locke et al. 2006).

Rio Grande wild turkeys (RGWT), which are distributed throughout the central and western portion of Texas, represent an economically important and increasingly popular game bird (Litton and Harwell 1995). Historically, the Edwards Plateau maintained large concentrations of RGWTs and served as a source for restocking areas throughout the United States (Peterson et al. 2002). Since the 1970s, Texas Parks and Wildlife Department biologists have documented a decline in turkey abundance based on

summer production surveys in portions of the Edwards Plateau (T. Wayne Schwertner, Texas Parks and Wildlife Department, personal communication). A reliable method for estimating wild turkey abundance at large spatial scales is required to better understand the cause(s) of this decline. Additionally, Texas Parks and Wildlife Department would prefer a method that estimates turkey densities on a regional scale primarily for establishing harvest regulations.

The goal of this study was to evaluate distance sampling for estimating Rio Grande wild turkey abundance in the Edwards Plateau, Texas. Specifically, I conducted pilot studies to determine the feasibility of both aerial and ground line transects. When applied properly, distance sampling offers estimates of density while taking into account probability of detection (Rosenstock et al. 2002). Distance sampling has provided unbiased estimates for other Galliformes (Ratti et al. 1983, Brennan and Block 1986, Guthery 1988) and DeYoung and Priebe (1987) noted the potential of line transects for broad application in estimating wild turkey densities. Additionally, distance sampling may be an efficient and cost effective method (Burnham et al. 1980) for estimating wild turkey numbers by state wildlife programs. Thus, the objective of my study was to conduct pilot studies in order to determine if line transects from an aerial or ground vehicle were viable for estimating Rio Grande wild turkey density in the Edwards Plateau ecoregion.

### **Study area**

The Edwards Plateau is located in the central portion of Texas and is approximately 9.7 million ha of predominately privately-owned land (Wilkins et al.

2003; Fig. 1.1). Often referred to as the Texas Hill Country or the Balcones Canyonlands, it consists of rolling hills and steep canyons, and ranges in elevation from approximately 30–915 m above ground level (AGL; Gould 1962). The climate is subtropical to semiarid, and mean annual precipitation ranges from 84 cm/year on the eastern edge of the plateau to 38 cm/year on the western edge and droughts occur frequently. The region is partly rangeland with various species of bluestem (*Andropogon* spp.), grama (*Bouteloua* spp.), and panicum (*Panicum* spp., Gould 1962). The remaining woodland includes semi-evergreen and evergreen species such as live oak (*Quercus virginiana*), and ashe juniper (*Juniperus ashei*). Deciduous species including bald cypress (*Taxodium distichum*), cottonwood (*Populus deltoides*), and pecan (*Carya illinoensis*) are found along riparian areas (Larkin and Bomar 1983).

## Methods

Aerial line transects were conducted on a private ranch near Medina, Texas, using a Robinson R-22 helicopter. The ranch was representative of Edwards Plateau topography and vegetation. Eleven parallel line transects were systematically established across the study area and spaced approximately 0.8-km apart for total transect length of 56 km. Line transects were flown for 5 consecutive days during December (leaf-off period). Flights were conducted in the mornings and evenings of each day, and the starting point was alternated to avoid temporal bias (Robbins 1981). Transects were flown at a constant speed (approx 37 km/hr) and altitude (approx 30 m AGL). Upon a turkey observation, the helicopter hovered on the transect line and the (1)

line transect number, (2) perpendicular distance to the center of the flock using a laser range finder, and (3) total number of turkeys in a cluster were recorded.

In addition to aerial line transects, transects ( $n = 26$ ) totaling 80-km were established on isolated county roads throughout the Edwards Plateau. Transects were randomly chosen and driven in AM (i.e., midmorning) or PM (i.e., late afternoon) of September 2005 when turkeys were expected to be active. Due to manpower constraints and to increase the sample size, 1 person drove a transect at a standard speed (32 km/hr). Upon observation of a turkey(s) the same information as aerial line transects was collected. Data were collected in both instances to determine if a sufficient sample size could be obtained.

## **Results and discussion**

Aerial line transects were flown morning and evening for 5 consecutive days totaling 560 km of total transect length. No turkeys were observed during flights and visibility was limited due to steep terrain and dense vegetation. Turkey observations along driven road transects also were limited by terrain and vegetation. Between 15 September and 20 September, 10 transects or 800 km of line transect was covered and 12 clusters of turkeys were observed. Neither method yielded a sufficient sample size to generate an unbiased estimate of the turkey abundance.

Turkey observations along aerial and ground transects were limited by hilly terrain and dense vegetation, and an increase in transect length would increase costs without generating an unbiased abundance estimate. Aerial surveys are advantageous when sampling a large area, but hilly or mountainous terrain can be problematic

(Buckland et al. 2001). This was the case in my study. Additionally, distance methods are only applicable when the species is highly detectable (Pollock et al. 2002). Wild turkeys are an elusive and highly mobile species (Beasom and Wilson 1992) making them difficult to detect. Large areas of live oak and juniper may have prevented turkey observations from an aerial perspective. Turkeys may have sought refuge in these areas upon hearing the helicopter, limiting our ability to observe them. Turkey observations along road transects also were limited due to dense vegetation and hilly terrain. Based on these results, line transects from the air or road are not an efficient means of obtaining an unbiased estimate of Rio Grande wild turkeys in the Edwards Plateau, Texas. The problems of dense vegetation and steep terrain are difficult to overcome. Unless methodologies are improved or the limitation of small sample size is corrected, I do not recommend the use of line transects from the ground or air to estimate Rio Grande wild turkey densities in the Edwards Plateau, Texas.



## CHAPTER V

### CONCLUSIONS AND IMPLICATIONS

Rio Grande wild turkeys (*Meleagris gallopavo intermedia*) are an elusive species inhabiting a wide range of areas throughout Texas where numerous practical and logistical constraints exist in attempting to obtain regional density estimates. The inability to obtain unbiased estimates of wild turkey abundance or trends has been a continual limitation of management programs (Cobb et al. 1997, Cobb et al. 2001). Although several methods of estimating wild turkey abundance have been examined, the majority were of limited success (Weinstein et al. 1995, Cobb et al. 2001).

Although Rio Grande wild turkeys have been a stronghold in the Edwards Plateau, Texas Parks and Wildlife Department (TPWD) biologists have recognized declines in turkey abundance within certain areas since the 1970s. These declines along with the desire to establish relevant harvest regulations prompted TPWD to seek methods to obtain regional density estimates of Rio Grande wild turkeys. Therefore, the objectives of my study were to:

1. Review current and past methods for estimating wild turkey abundance (Chapter II).
2. Evaluate the use of portable thermal imagers to estimate roosting wild turkeys in 3 ecoregions (Chapter III).
3. Determine the effectiveness of distance sampling from the air and ground to estimate wild turkey densities in the Edwards Plateau Ecoregion of Texas (Chapter IV).

## **Literature review**

I reviewed current and past methods for estimating wild turkey density to determine the most suitable for field evaluation. The methods reviewed included: roost and flock counts, distance sampling, aerial surveys, infrared imagery, mark-recapture/resight, bait station cameras, removal methods and map plotting techniques. A decision matrix was created with a list of *a priori* criteria for evaluating each method. Criteria included methods that were: (1) technically practical (e.g., could the method be implemented in the Edwards Plateau with current manpower and equipment available), (2) economically feasible (would the method be cost-effective for TPWD to conduct on annual or semi-annual basis), (3) adequate accuracy and precision (satisfactory accuracy and precision to facilitate management decisions), and (4) method could be conducted without violating underlying assumptions.

Based on the decision analysis results (Fig. 2.1, Chapter II), I identified 2 methods for field evaluation including: (1) aerial sampling of roost sites using forward-looking infrared and (2) distance sampling methods from an aerial and ground perspective. These methods were then evaluated in the field via pilot studies.

## **Evaluation of portable infrared cameras**

Forward-looking infrared (FLIR) technology has gained recent attention for its use in wildlife surveys (Garner et al. 1995, Thompson 2004); however, FLIR has primarily been used for large ungulate species (Wiggers and Beckerman 1993, Naugle et al. 1996, Adams et al. 1997). Few studies have evaluated the ability of FLIR to detect and survey smaller animals such as wild turkeys. My objective was to evaluate FLIR for

detecting roosting Rio Grande wild turkeys in 3 ecological regions (Edwards Plateau, Rolling Plains, and Gulf Prairies and Marshes).

Detection of roosting turkeys was limited in all 3 regions due to flight altitude, topography, and lack of thermal contrast. In the Edward Plateau, all 3 limitations were present. The steep terrain and obstacles (e.g., power lines, utility towers) prevented lower, optimal flight altitudes required to detect roosting turkeys. Additionally, thermal contrast between turkeys and their surroundings was insufficient for detection. Turkeys were detected from the ground in the Rolling Plains but not from the air due to the lack of thermal contrast. The lack of detection in the Gulf Prairies and Marshes was primarily a result of vegetation. Turkeys roosted in live oak (*Quercus virginiana*) which obscured the thermal signatures of turkeys. However, roosting turkeys were detected in the Rolling Plains from the ground but not from the air. With roost sites limited to riparian areas within the Rolling Plains and advancements in FLIR technology in the future, this method may have potential to be successful. The Rolling Plains are predominately flat in comparison to the Edwards Plateau thus allowing for optimum flight altitude to detect turkeys. Without advancements in technology, I would not recommend the use of FLIR for estimating Rio Grande wild turkey numbers.

### **Evaluation of line transects**

Distance sampling provides density estimates while taking into account probability of detection (Rosenstock et al. 2002). Other studies (Ratti et al. 1983, Brennan and Block 1986, Guthery 1988) have used distance sampling to produce unbiased estimates of other Galliformes and DeYoung and Priebe (1987) noted the

potential of line transects in estimating wild turkey densities on a broad scale. I evaluated line transects from the air and ground for estimating Rio Grande wild turkey densities in the Edwards Plateau, Texas.

Aerial line transects were flown in December 2005 for 5 consecutive days totaling 560 km of total transect length. In September 2006, 10 transects or 800 km of line transect was covered and 12 clusters of turkeys were observed. No turkeys were observed during the aerial surveys while only 12 clusters of turkeys were observed from ground transects. Both air and ground transects were limited by hilly terrain and dense vegetation that limited detection of wild turkeys. Neither method yielded a sufficient sample size to generate a reliable or unbiased estimate of turkey density. Therefore, I would not recommend the use of line transects to estimate Rio Grande wild turkeys in the Edwards Plateau, Texas.

### **Implications**

The use of thermal imagers to detect roosting wild turkeys or the application of distance sampling from an aerial or ground perspective were promising yet largely untested methods for estimating Rio Grande wild turkey abundance. However, I found none of the methods performed satisfactorily. The methods were limited by the lack of thermal contrast between roosting turkeys and their background in 3 Texas ecoregions (i.e., FLIR, Chapter III) in addition to, the hilly terrain and dense vegetation present in the Edwards Plateau of Texas (i.e., distance sampling, Chapter IV). The vegetation, terrain, and amount of private land in the Edwards Plateau constrained my ability to obtain reliable and unbiased estimates of Rio Grande wild turkey abundance.

Based on the results of this study, it is my opinion that currently in the Edwards Plateau, there is no method capable of estimating Rio Grande wild turkey densities on a regional scale. The methods reviewed including those evaluated were each flawed for various reasons. Winter roost counts (Cook 1973) have provided the best attempt for estimating Rio Grande wild turkey numbers in the Edwards Plateau. However, winter roost counts may only provide a viable option on a small scale such as the ranch level. I believe roost counts should be conducted by trained personnel to avoid landowner biases, but this would be costly and time consuming on a regional scale. Additionally, harvest data and hen/poult counts collected by TPWD may continue to provide trends of turkey numbers for regions. As Butler (2006) suggests, hen/poult counts as currently conducted suffer from inadequate sample size and uneven coverage of area of inference. In order to be effective, hen/poult counts need to evenly cover the area of inference and surveys should be randomized and standardized. Presently, trends or indices of Rio Grande wild turkey abundance on a regional scale may be the best turkey managers can ask for.

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